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LOCK CYLINDER

The invention pertains to a lock cylinder of the type indicated in the introductory clause of Claim 1. The lock cylinder consists of a cylinder housing and a cylinder core, rotatably supported in the housing. A key with a defined longitudinal key profile is assigned to the lock cylinder and can be inserted into the cylinder core to actuate it by rotation. A group of diametric shafts in the cylinder core are arranged in an axial row; the shafts hold plate-shaped tumblers, which can slide longitudinally inside the shafts under the guidance of their longitudinal edges. The tumblers are spring-loaded in one of their two directions of movement and have control edges at defined heights, these edges being designed in conformity with the longitudinal profile of the key. In the resting position, that is, when the key is not present in the core, the tumblers engage in a locking channel in the cylinder housing. When the key is inserted and again when it pulled out, the tumblers can escape temporarily into an escape channel of the cylinder housing, which is diametrically opposite the

locking channel.

The security of a lock system depends on whether or not picking tools can be used to determine the position of each of the control edges of the individual tumblers. Unless special precautions are taken, the height of the control edges can be detected either directly by determining the resting position of the tumblers in the key channel or indirectly by using a tool to push the tumblers down one after the other into the escape channel against their spring-loading and by determining the extent of this setback movement of the tumblers against the spring-loading. If this process is successful, unauthorized persons can establish the longitudinal profile of the key and, on the basis of this knowledge, fabricate a copy.

To prevent this, the effort has been made to conceal the actual positions of the control edges on the tumblers by providing stops on the tumblers and opposing stops on the cylinder housing. In the known lock cylinder of this type (DE 28 15 380 C2), axially parallel longitudinal ribs are provided in the locking channel and in the escape channel of the cylinder housing, and the tumblers are provided on their terminal plate edges with cutouts of various depths. The depths of the cutouts are selected so that, for example, the control edges of the

tumblers, which are at different heights, will all come to rest on the same height line in the resting state. The idea of positioning all the control edges at the same height was also used as a defense against the indirect picking method in which the tumblers are pushed back against their spring-loading into the escape channel by a picking tool.

Although it was thus possible to mask the positions of the control edges of the individual tumblers, it became more difficult, in the absence of supplemental measures, to assemble the lock cylinder for the following reason. As long as the cylinder core is still outside the cylinder housing, the springs try to push the tumblers out of their shafts in the core; and unless sufficient care is taken, the springs can even catapult the tumblers completely out of the shafts. To prevent this, it was necessary to search for additional measures to prevent the loss of the tumblers.

The loss prevention measure has the job of holding the tumblers temporarily in their shafts after their insertion in the cylinder core despite the fact that the springs are trying to push them out. In another known lock cylinder, a tooth pointing into the interior of the shaft is formed for this purpose on one of the guide edges of the shaft. The tooth has a

steep blocking flank and a flat flank. A cutout with a step at the end is provided on the corresponding longitudinal plate edge of the tumbler. The steep flank of the tooth cooperates with the step on the longitudinal edge of the tumbler to prevent the loss of the tumbler. If it is also desired to conceal the position of the control edges, the positions of the step and of the cutout in the tumbler must be selected in conformity with the height position of the control edge.

In the case of the known lock cylinder, therefore, two different measures are required to conceal the positions of the control edges and to prevent the tumblers from being lost during the assembly of the cylinder core. Whereas the known stops and counterstops for concealing the positions of the control edges act between the tumblers and the cylinder housing, the means for preventing the loss of the tumblers act between the tumblers and the cylinder core.

The invention is based on the task of developing a simple, low-cost lock cylinder of the type indicated in the introductory clause of Claim 1 which cannot be picked because of the concealment of the position of the control edges and which is also characterized by a reliable loss-prevention system. This is accomplished according to the invention by the alternative

measures cited in Claim 1, to which the following special meaning attaches.

A projection on one of the longitudinal plate edges of the tumbler extends out from the interior of the shaft and cooperates with the associated guide surface of its assigned shaft, which is provided with a cutout area to accept this projection. The lobe has two longitudinal flanks, and the cutout area has two opposing counterflanks. The lobe and the cutout have initially two functions. One of the flanks of the lobe functions as a stop, and the inner surface of the cutout facing this flank functions as a counterstop, as a result of which the actual position of the control edge of the tumbler is concealed. In contrast to the state of the art, however, the cylinder housing does not participate in the concealment of the positions of the control edges; in the invention, the concealment is produced entirely between the cylinder core and the tumbler. The cylinder housing in the invention can be designed neutrally. The flanks and the counterflanks allow the tumbler to travel only a limited distance into the locking channel and into the escape channel.

The flank of the lobe facing in the direction of the spring-loading and the counterflank facing in the opposite

direction, however, simultaneously fulfill the function of loss prevention. In spite of their spring-loading, the tumblers which have been inserted into the cylinder core are held in place even before the core is installed in the cylinder housing. The tumblers and the cylinder core form a unit which can be preassembled. For this purpose, the invention proposes two alternatives, one of which is described in the characterizing clause of Claim 1, the other in the characterizing clause of Claim 9. The first alternative is explained in greater detail on the basis of an exemplary embodiment described below in conjunction with Figures 1.1-2.2b, and the other alternative is explained on the basis of three exemplary embodiments illustrated in Figures 3.1a-8.4b.

Additional measures and advantages of the invention can be derived from the subclaims, from the following description, and from the drawings. In the drawings, the invention is, as previously mentioned, illustrated on the basis of a total of four exemplary embodiments. In the first exemplary embodiment, four different cross-sectional views through the lock cylinder are shown:

-- Figures 1.1a-2.2a show cross-sectional views through the lock cylinder in its resting position in the area of one of four

different tumblers, the control edges of which are each at a different height;

-- Figures 1.1b-2.2b show the same cross-sectional views of the same lock cylinder after the tumblers have been pushed down as far as possible into the escape channel.

The second exemplary embodiment is illustrated by two cross sections through a modified second lock cylinder:

-- Figures 3.1a + 3.2a, in analogy to Figures 1a and 2a, show two cross-sectional views through the second lock cylinder in its rest position in the area of two tumblers, the control edges of which are at different heights.

The third exemplary embodiment is illustrated by six cross sections through a third lock cylinder, which again represents a modification of the two preceding cases:

-- Figures 4.1a-5.3a, in analogy to Figures 1.1a-2.2a, show cross-sectional views through a third lock cylinder in its rest position in the area of six tumblers with control edges at different heights; and

-- Figures 4.1b-5.3b, in agreement with Figures 1.1b-2.2b, show the same cross-sectional views of the third lock cylinder as those of Figures 4.1a-5.3a, except that here the tumblers have been pushed down as far as possible into the escape

channel.

A fourth exemplary embodiment of a fourth lock cylinder, again representing a modification of the preceding cases, is illustrated in the following figures:

-- Figure 6 shows a highly magnified, perspective view of a comb, which can be inserted into the cylinder core of the fourth lock cylinder (not shown), and two tumblers, the control edges of the which are at the same height;

-- Figures 7.1a-8.4a, again in analogy to Figures 1.1a-2.2a, show eight cross-sectional views through a fourth lock cylinder in its rest position in the area of eight tumblers, the control edges of which are in some cases at different heights; and finally

-- Figures 7.1b-8.4b show the corresponding cross-sectional views of the fourth lock cylinder after, in analogy to Figures 1.1b-2.2b, the tumblers have been pushed down as far as possible.

The lock cylinder shown in Figures 1.1a-2.2a comprises a cylinder housing 10.1 with a bearing bore 11 for a cylinder core 20.1. The cylinder core 20.1 has a group of diametric shafts 23.1, arranged in a row, one behind the other, in each of which one of four different plate-shaped tumblers 31.1-34.1 is held.

The longitudinal plate edges 30.1, 30.2, which are profiled in a particular way here, are guided along appropriate guide surfaces 21.1, 21.2 of the shaft 23.1, these guide surfaces being located on the inner, narrow sides of the shaft 31.1. Each of the shafts 23.1 is provided in the conventional manner with an expansion 24.1, in which a compression spring 15.1 is located. One end of the compression spring 15.1 is supported against an end surface 25 of the expansion 24.1, whereas the opposite end grips a projection 35.1, which extends outward from the longitudinal plate edge 30.2 present there and into the expansion 24.1 of the shaft. As a result, the tumblers 31.1-34.1 are spring-loaded in the direction indicated by the force arrow 13.1.

The tumblers 31.1-34.1 have control edges 41.1-44.1, which are at four different heights 45-48 with respect to the height center line designated 40, shown in broken line as 40.1 in Figures 1.1a-2.2a, of the associated tumbler 31.1-34.1. In Figure 1.1a, the control edge 41.1 is located at a first step height 45. The control edge 42.1 in Figure 2.1a is at a second step height 46, whereas the control edge 43.1 in Figure 2.2a is at a third step height 47. Finally, the control edge 44.1 of Figure 2.2a is at a fourth step height 48. The control edges

41.1-44.1 in the present exemplary embodiment are located on a tongue 69, which projects into a window 70 in the associated tumbler 31.1-34.1. The edge of the tongue 69 which serves as the control edge 41.1-44.1 is that which faces in the direction of the spring-loading 13.1.

The assigned key (not shown) has a flat profile, which matches the open width of the previously mentioned window 70 in the tumbler 31.1. The reason for the previously mentioned design of the control edge is that the flat key has its analogous opposing control edges on one or on both of its wide sides. These opposing control edges along the lateral control face of the key determine its individual longitudinal profile. When the tumblers 31.1-34.1 are to be installed in the successive shafts 23.1 of the cylinder core 20.1, as will be described in greater detail below, the tumblers 31.1-34.1 are selected and arranged in sequence in accordance with the opposing control edges of the longitudinal profile of the associated key.

Without the special inventive measures to be cited further below, the tumblers 31.1-34.1, because of their spring-loading 13.1, would all travel the same distance into the locking channel 12.1 provided in the cylinder housing 10.1 when in the

rest position, that is, after the key has been withdrawn. The insertion depth is determined by means familiar from the state of the art, such as by the contact of the spring-supporting projection 35.1 against the bearing bore 11 of the cylinder housing 10.1. In this case, however, it is possible to insert a feeler into the key channel up to the individual windows 70 of the tumblers 31.1-34.1 and thus to detect the positions of the control edges 41.1-44.1. This knowledge can then be used to produce an unauthorized copy. This would put the security of the lock cylinder at risk.

Another possibility of a similar type of unauthorized detection process would be to insert a lock-picking tool into the windows 70 of the various tumblers 31.4-34.4 and to push the control edges 41.1-44.1 down so far that the terminal plate edges 39 of the tumblers in question meet the bottom surface 14 of the escape channel 16.1. The escape channel 16.1 is located in the cylinder housing 10.1 diametrically opposite the locking channel 12.1. The escape channel 16.1 normally serves to allow the tumblers 31.1-34.1 to move out of the way when the key is being inserted. With the picking tool, the extent of the setback movement of the individual tumblers could be determined in this case, whereupon it would be possible to determine the

height of the control edges 41.1-44.1 in the individual tumblers 31.1-34.1. This knowledge could again be used to produce an unauthorized copy. All this is prevented according to the invention for the following reason.

A lobe 36.1 is provided on one of the longitudinal plate edges 30.1 of each tumbler. If we ignore for the moment the projection 35.1 for the spring, the tumbler, as illustrated in Figure 2.1a, has a width 19 in the lobe area, as shown in Figure 2.1a, which is greater than the open width 29 of the shaft 23.1. The lobe 36.1 therefore projects from the longitudinal plate edge 30.1. A cutout 26.1 in the cylinder core, however, is provided to accommodate the lobe 36.1, which projects into the cutout.

In the resting case, that is, in the absence of the key, the lobe 36.1, as shown in Figure 2.1a, is supported by its flank 37.1, i.e., the flank facing in the direction of the spring-loading 13.1, against the opposing flank 27.1 of the cutout 26.1, this flank facing in the opposite direction. This support fulfills three different functions according to the invention, as can be derived from the following explanation.

These three functions are based on the stop action between the previously mentioned lobe flank 37.1 and the opposing flank

27.1 of the cutout. This stop action prevents any further outward movement of the tumbler in question from the cylinder core 20.1 -- movement which otherwise would be possible in and of itself. The first function is to render ineffective all of the other stops which are conventional in the state of the art for limiting the outward movement of the tumblers. For example, there is no longer any stop action between the projection 35.1 for the spring and the bearing bore 11 in the cylinder housing 10.1. In addition, as can be seen in Figure 2.1a and Figure 2.2a, there is a gap of greater or lesser width present in the resting position between the upper terminal plate edge 49 of the tumbler 31.1 or 31.4 in question and the bottom surface 17 of the locking channel 12.1.

The second function of the previously mentioned stop action consists in that it conceals the actual position of the control edges 42.1 and 44.1. As a comparison of Figure 2.1a with Figure 2.2a shows, the control edges 42.1 and 44.1 are located at identical heights, characterized by the auxiliary line 50.2, even though, relative to the height center line 40.1 of the tumblers 32.1, 34.1, they are located in the one case at the second step height 46 and in the other case at the fourth step height 48. If we want to determine the height of the control

edges by the use a feeler, it is impossible to decide whether tumbler 32.1 or tumbler 34.1 is present in this position in the lock cylinder, and thus it is impossible to determine the actual height 46 or 48 of the control edges 42.1 and 44.1.

The previously mentioned concealment of the positions of the control edges is achieved simply in that, in Figure 2.1a, the lobe 36.1 on the tumbler 30.2 of Figure 2.2a is situated lower than the corresponding lobe 36.1 on the tumbler 30.4 shown in Figure 2.2a. This lobe flank 37.1 in Figure 2.2a coincides essentially with the height center line 40.1, whereas, in Figure 2.2a, the corresponding lobe flank 38.1 of the tumbler 34.1 is offset by a distance 18 from the height center line 40.1 present in that case. In the present exemplary embodiment, the height offset 18 is approximately the same as the height of the lobe between its two flanks 37.1, 38.2.

By means of an analogous height offset, it would be possible to bring the control edges 41.1 and 43.1 of the other tumblers 31.1 and 32.1 shown in Figures 1.1a and 1.2a into the previously mentioned height position 50.2 of Figures 2.1a and 2.2a. For design reasons, however, it is easier and also sufficient for the purpose of concealment for the control edges 41.1, 43.1 in the resting condition to be at a height 50.1 which

is different from the previously described height position 50.2 of Figures 2.1a and 2.2a. Relative to the opposing flanks 27.1 of the cutout in the cylinder core 20.1, all of which are on the same level in the present case, the control edges 44.1 and 42.1 are, when in the resting state, at the same height 50.2 versus their opposing flanks 27.1, as can be derived from Figures 2.2a and 2.1a. According to Figures 1.1a and 1.2a, the height position 50.1 of the two other control edges 41.1 and 43.1 of the tumblers 30.1 and 30.3 are a shorter distance 51 away from the opposing flanks.

A third essential function of the previously mentioned stop action between the lobe flank 37.1 and the opposing flank 27.1 of the cutout consists in so-called "loss prevention". That is, the previously mentioned stop action remains in effect even when the cylinder core 20.1 and its spring-loaded tumblers 30.1-34.1 are outside the cylinder housing 10.1. The shafts 23.1 in the cylinder core 20.1 are open at both ends, for which reason, unless the inventive stop action were not provided at 37.1, 27.1, the tumblers 31.1-34.1 would be catapulted out of the cylinder core 20.1 under the action of the spring-loading 13.1. This stop action offers the advantage that the cylinder core 20.1 and its various tumblers 31.1-34.1 are held together

independently of the cylinder housing 10.1. The tumblers 31.1-34.1 can never travel farther outward than allowed by the flanks 27.1, serving as stops, and their associated opposing flanks 27.1, serving as counterstops. For this reason, it is possible according to the invention to preassemble a unit consisting of the cylinder core 20.1 and all of the tumblers 31.1-34.1, including their springs 15.1. Such a unit can be easily stored and transported and then installed as needed in the bore 11 of a cylinder housing 10.1. A defective lock cylinder can be easily repaired by replacing the unit in question.

Even though, as explained on the basis of Figure 2.1a, the width 19 of the tumblers 31.1-34.1 in the area of the lobe 36.1 is greater than the open width 29 of the shaft, they can still be introduced into the cylinder core 20.1 by means of a slanted insertion technique, described in greater detail below. As can be seen in Figure 1.2a, the lobe 36.1 is seated on a web 53 of the tumbler, which is profiled in the longitudinal direction. The longitudinal edge 30.1 of the plate forming the tumbler 33.1 has two cutouts 54, 55, which proceed from the base of the lobe 36.1 and thus make the web 53 narrower. The lobe 36.1 is located between these two cutouts 54, 55. The cutouts 54, 55 make it possible for the individual tumbler to be pivoted into

the shaft 23.1 by means of a rotation-insertion movement around the edge of the shaft opening of the cylinder core 20.1. To facilitate this turning movement which forms part of the insertion process, the projection 35.1 can be provided with a suitable outline 56 as shown in Figure 2.2a. Finally, the insertion process can take advantage of a certain intrinsic elasticity of the tumbler web 53. For this purpose, the web 53 is suitably thinned out or profiled. The cutouts 54, 55 themselves are already sufficient for this. During the insertion process, the elasticity of the tumbler web 53 means that the lobe 36.1 on the web will snap into the cylinder core cutout 26.1 and will be trapped there. Thus the desired loss-prevention function goes into effect.

As already mentioned above in the description of the figures, Figures 1.1b-2.2b show the same cross sections as the analogous Figures 1.1a-2.2a, except that here the tumblers have been pushed down as far as possible by a lock-picking tool (not shown). Even in this pushed-down position, the ability of the tumblers 31.1-34.1 to escape into the escape channel 16.1 of the cylinder housing 10.1 is limited. The stop action between the lobe 36.1 and the cylinder core cutout 26.1 is used for this purpose. In the pushed-down position, however, the

participating elements are the flank 38.1 and the opposing flank 28.1 of the cutout 26.1. The result is as follows.

As a result of the stop action, as Figures 1.1b and 2.1b show, the two control edges 41.1, 43.1 both arrive, when in the pushed-down position, at the same height position, labeled 60.1, in the shaft 23.1 of the cylinder core 20.1. This means again that the actual height positions 45, 47 of these control edges 41.1, 43.1 with respect to the associated height center line 40.1 of the tumblers 31.1, 33.1 are concealed. The same thing happens when the two other tumblers 32.1, 34.1 are pushed down as shown in Figures 2.1b, 2.2b. The associated control edges 42.1, 44.1 are now at the height in the cylinder core 20.1 characterized by the line 60.2, as a result of which the actual height positions 46, 48 are concealed.

In the present exemplary embodiment, the lobes 36.1 of all the different tumblers 31.1-34.1 are designed in the same way. The same is also true for the cutouts 26.1, the flanks 27.1 and 28.1 of which are aligned axially with each other in the cylinder core 20.1. Based on the positioning of their lobes 36.1, the tumblers 31.1-34.1 in the present exemplary embodiment can be divided into two groups. One group consists of the tumblers 31.1 and 32.1 shown in Figures 1.1a and 2.1a. For

them, as already mentioned, the flank 37.1 of the lobe 36.1 facing in the direction of the spring-loading 13.1 is aligned with the associated height center line 40.1 of the two tumblers. The other group is formed by the tumblers 33.1 and 34.1, as can be seen in Figures 1.2a and 2.2a. Here, as already pointed out, it is the flank 38.1 of the lobe 36.1 which is aligned with the height center line 40.1 of these tumblers.

To increase the resistance to being broken open by lock-picking tools, the inventive lock cylinder, as can be seen in Figure 2.2b, is provided with sets of teeth 57, 58, and 59. The sets of teeth 57 are located at the ends of the two longitudinal plate edges 30.1, 30.2. Opposing sets of teeth 58, 59 cooperating with them are located on the lateral surfaces of the locking channel 12.1 at one end and on the lateral surfaces of the escape channel 16.1 at the other. When the attempt is made to manipulate the tumblers 31.1-34.1, the sets of teeth 57 lock together with the opposite sets of teeth 58, 59.

Figures 3.1a and 3.2a show a second exemplary embodiment of the invention. Although the reference numbers used here are the same those used for the analogous parts in the above first exemplary embodiment, they are followed by ".2" here instead of by ".1". It is sufficient to discuss only the differences. The

preceding description applies to all else.

As can be derived from Figure 3.1a, the cylinder core 20.2 has a radial opening 61.2 leading from the shaft 23.2. In the first phase of the assembly process, the compression springs 15.2 are inserted into the individual expanded shaft areas 24.2, and then the plate-shaped tumblers 31.2, 33.2 are pushed into their respective shafts 23.2 as required by the code of the key.

In the next phase of the assembly process, the tumbler 31.2 is secured in its position by an insert 62.2, which is pushed radially into the opening 61.2. The insert 62.2 is pushed in until its inner end 64.2 projects into the shaft 23.2. This projecting part of the inner end 64.2 is called the "lobe" in the following, in analogy to the use of the term in the first exemplary embodiment, and is designated by the reference number 36.2. This lobe 36.2 also has two flanks 37.2, 38.2, facing in the directions of the longitudinal movement of the tumbler 31.2.

The reason why it is possible to form a lobe 36.2 is that the associated tumbler 33.2, as explained in greater detail on the basis of Figure 3.2a, has a cutout 26.2 on the longitudinal plate edge 30.2 facing the lobe 36.2. In analogy to the first exemplary embodiment, this cutout has two opposing counterflanks 27.2, 28.2. The outer end 63.2 of the insert 62.2 is designed

to be flush with the cylindrical outline 65 of the cylinder core 20.2, as can be seen in Figure 3.1a.

As shown on the basis of Figures 3.1a and 3.2a, it is possible with these measures to conceal the actual positions of the control edges 41.2, 43.2 according to Figures 3.1a and 3.2a. The flanks 37.2, 38.2 of the lobe 36.2 formed by the insert 62.2 in the present case occupy the same height position in the lock cylinder 20.2 in all of the shafts 23.2. The individual openings 61.2 and the inserts 62.2 to be installed in them are all of the same shape. The length of the cutout 26.2, designated 66.2 in Figure 3.2a, is also the same for all of the plate-shaped tumblers 31.2, 33.2 in the present exemplary embodiment. The cutouts 26.2, however, occupy different positions along the length of the associated tumbler 31.2, 33.2, depending on the associated control edge 41.2, 43.2. This is what accounts for the "concealment" which is achieved.

As in the preceding exemplary embodiments, the height center lines 40.2 in the tumblers 31.2, 33.2 are shown in broken line in Figures 3.1a and 3.2a. The opposing flank 27.2 of the cutout 26.2, labeled in Figure 3.2a, functions as a stop. Relative to the center line 40.2, this flank is lowered as a function of the position of the control edge 41.2, 43.2 by an

amount 67.1, 67.3, as can be seen in both Figure 3.1a and in Figure 3.2a. This offset of the opposing flanks 27.2 is selected so that, in the resting case, according to Figures 3.1a and 3.2a, the control edges 41.2, 43.2 of the tumblers 31.2', 33.2 occupy identical height positions 50.3 in the lock cylinder. Thus the same effects as those of the first exemplary embodiment are obtained.

Another action consists in the "loss prevention" function, already described in great detail on the basis of the first exemplary embodiment. A unit consisting of the tumblers 31.2, 33.2, the springs 15.2, the insert 62.2, and the cylinder core 20.2 can also be preassembled in accordance with the second exemplary embodiment of Figures 3.1a and 3.2a. This unit can then be installed in and/or removed from a neutral lock cylinder 10.2 without fear that the spring-loaded tumblers 31.2, 33.2 will be lost.

It would also be possible, however, to modify the measures of the first exemplary embodiment according to Figures 1.1-2.2b in a manner analogous to the design of the second exemplary embodiment according to Figure 3.1a. That is, a filler piece open toward the tumbler shaft 23.1 could be installed in a radial opening in the cylinder core 20.1. The filler piece has

a cutout with a certain profile and can thus serve in place of the cutout 26.1 used in the first exemplary embodiment. Filler pieces with different profiles, therefore, can be used to change conveniently and quickly the position of the opposing flanks 26.1 and 28.1 of the now modified cutouts 26.1 in the cylinder core 20.1.

The third exemplary embodiment according to Figures 4.1a-5.3b works according to the same principle as the previously described second exemplary embodiment of Figures 3.1a, 3.2a. The same reference symbols as those used for the two preceding exemplary embodiments will therefore be used again to designate analogous parts, except that, to differentiate them from each other, the numbers are followed here by ".3". It is sufficient to explain only the differences from the second exemplary embodiment. The preceding description applies otherwise to all else.

In the third exemplary embodiment, an insert 62.3 is used, which has a lobe 36.3 at the inner end 64.3, which can be seen in Figure 4.1a. This lobe has a special convex profile facing in the radial direction. Several pairs of flanks of different heights are arranged in the longitudinal displacement of the tumbler 31.3 shown here. In the present case, two pairs of

flanks are provided, which are to be referred to as the inner flank pair 37.3i, 38.3i and the outer flank pair 37.3a, 38.3a based on their positions relative to the highest point of the lobe. Although all of the inserts 62.3 have the same lobe profile at their inner end 64.3, and are seated in similar openings 61.3 of the cylinder core 20.3, they are positioned there in two laterally reversed positions, as can be seen on the basis of their profiles.

A transverse plane 71.3, which extends transversely to the direction of the spring-loading 13.3 and passes through the axis of the cylinder, is marked in broken line in Figures 4.1a-5.3b. The centers of the previously mentioned lobes are located on this plane. The inner flank pair 37.3i, 38.3i is symmetric to the transverse plane 71.3 and has flanks which are essentially parallel to the transverse plane 71.3. The outer flank pair 37.3a, 38.3a is asymmetric to the transverse plane 71.3, extending at a certain angle to that plane. In addition, the outer flank 37.3a is shorter than the other flank 38.3a.

This design has the result that the stops thus produced assume different positions when, as previously said, the positions of the inserts 62.3 are laterally reversed in the cylinder core 20.3. This can be seen on comparison of Figure

4.1a with Figure 4.3a. In Figure 4.1a, the insert is in its normal position 62.3, which means that it can be called the "normal insert". Here the shorter flank 37.3a is facing in the direction of the spring-loading 13.3. In Figure 4.3a, however, the same insert is in the laterally reversed position 62.3', for which reason an insert in this position is called the "mirror-image insert". Thus the previously mentioned inner and outer flanks have changed places with each other. The shorter flank 37.3a is now facing in the direction opposite the spring-loading 13.3 in Figure 4.3a. Because of its mirror-image position, the associated lobe will be designated 36.3' and be called the "reversed lobe". The lobe profiles 36.3, 36.3' are laterally reversed with respect to the transverse plane 71.3.

As in the case of the second embodiment, the cutouts in the third exemplary embodiment are located in the area of the tumblers 31.3-34.3 and are also of similar design. As can be seen on the basis of Figures 4.1b-5.3b, however, the various cutouts differ in their dimensions from each other as a function of the position of the associated control edge 41.3-44.3, and they also occupy different height positions. Common to all, however, is that the cutouts 26.3 are designed with two steps and that they have two different pairs of opposing flanks at

different depths of the cutout. On the lower step of the cutout 26.3, as can be seen in Figure 4.1b, there is an inner pair 37.3i and 38.3i of opposing flanks on the interior facing surfaces. On the upper step, the interior surfaces of the cutout 26.3 have an outer pair of opposing flanks 27.3a and 28.3a. In the same way as explained for the lobe, the inner opposing flanks 27.3i, 28.3i are again designed differently from the outer flanks 27.3a, 28.3a. The inner opposing flanks 27.3i, 28.3i are essentially parallel to the previously mentioned transverse plane 21.3 of the cylinder core 20.3, whereas the outer flanks 37.3a, 38.3a are at a certain angle to that plane. In the present case, the two outer opposing flanks 37.3a, 38.3a are essentially mirror images of each other. These design measures lead to the following results.

As previously mentioned, Figures 4.1a-5.3a show the rest position of the lock cylinder after the key has been removed. As a result, as already explained above on the basis of the first and second exemplary embodiments, the stops 36.3, 36.3' of the normal insert 62.3 and of the mirror insert 62.3' come to rest against the opposing stops of the opposing flanks of the tumbler cutout 26.3 in the following manner. When the inserts 62.3 and the mirror inserts 62.3' are positioned in the manner

shown with respect to the tumblers in the cylinder core 20.3, the previously described control edges of the individual tumblers 31.3, 32.3, and 33.3 come to rest in the height position 50.4 according to Figures 4.1a-4.3a. The stop-counterstop action comes about then, according to Figure 4.1a, through the interaction of the inner opposing flank 28.3i (see Figure 4.1b) of the tumbler 31.3 with the flank 38.3i of the normal lobe 36.3. In contrast, in the case of the tumbler 32.3 according to Figure 4.3a, the lobe of the mirror insert 62.3' is now the "reversed lobe" 36.3', which means that the outer opposing flank 28.3a of the cutout now rests against the outer flank 37.3a of the lobe, which is now facing in the direction away from the spring-loading 13.3. The same situation results in the case of the tumbler 33.3 in Figure 4.2a.

As can be derived from Figures 5.2a and 5.3a, the two latter tumblers 32.3 and 33.3 can also be positioned in a different height position 50.5, which is in line with the control edge 42.3 of the fourth tumbler 34.3. This is so, because, in Figures 5.2a and 5.3a, the normal inserts 62.3 are inserted into the cylinder cores 20.3, whereas, in the case of the tumbler 34.3 of Figure 5.1a, a mirror insert 62.3' is used. Therefore, a different set of flanks and opposing flanks,

namely, 38.3a and 28.3a, come to rest against each other in Figures 5.2a and 5.3a. In Figure 5.1a, however, the inner opposing flank 28.3i of the tumbler 34.3 rests against the inner flank 37.3i of the mirror insert 62.3'.

As previously mentioned, Figures 4.1b-5.3b show positions analogous to those of Figures 4.1a-5.3a of the third exemplary embodiment after a lock-picking tool has been used to push the tumblers 31.3-34.3 down as far as possible. The tool presses the tumblers 31.3-34.3 down against their spring-loading 13.3. Then the stops go into action again, and depending on whether at this point a normal insert 62.3 or a mirror insert 62.3' is present, they bring the associated control edges 41.3-44.3 either into the height position 60.3 or into the height position 60.4. That the positions of the tumblers 33.3 and 32.3 in Figure 4.2b and Figure 4.3b are different from those they occupy in Figure 5.2b and Figure 5.3b is again a function of whether a mirror insert 62.3' or a normal insert 62.3 is used. The flanks and opposing flanks which go into action thus differ in the two cases

The various inserts 62.2, which are inserted into the cylinder core 20.2 of the second exemplary embodiment, and the inserts 62.3, 62.3', which are inserted into the cylinder core

20.3 of the third exemplary embodiment, can also be connected to each other axially in certain areas, preferably in the area of the outer ends 63.2, 63.3, to facilitate the insertion operation. This can be explained in a very concrete manner on the basis of Figure 6 of the fourth exemplary embodiment, the lobes and cutouts of which are based on a similar design principle. In this case, too, the corresponding reference numbers are used to designate analogous parts, with the difference that here most of the number are followed by ".4". Only the differences need to be discussed. The preceding description applies to all else.

Figure 6 is a perspective view of the , which are permanently connected to each other in the area of their outer ends 63.4 and which therefore form the "teeth" of a comb-like body 68, which is referred to below as the "comb". In the fourth exemplary embodiment, we again have inserts with similar profiles at their inner ends 64.4; these profiles form the lobes 36.4. The inserts, however, are again arranged in two different laterally reversed positions in the comb 68, namely, in a series alternating between normal inserts 62.4 and mirror inserts 62.4'. In the case of the mirror inserts 62.4', the lobes 36.4 occupy a laterally reversed position 36.4' and are thus to be

called "reversed lobes" again. The comb 68 can then be handled as a single unit for insertion of the inserts 62.4, 62.4'. The associated radial openings 61.4 in the cylinder core 20.4 shown in Figures 7.1a-8.1a are all of the same shape.

As a comparison of Figure 7.1a with Figure 7.2a shows, the normal lobe 36.4 and the reversed lobe 36.4' are located at the maximum distances 72, 72' from the transverse plane 71.4, shown in dash-dot line, and as already described in conjunction with the third exemplary embodiment; and because of the alternating normal and reversed positions, as can be seen in Figure 6, the normal lobe 36.4 and the reversed lobe 36.4' are positioned either at the upper end 73 or at the lower end 73' of the associated insert 62.4, 62.4'. As previously mentioned, the flank profiles of the normal lobe 36.4 and the reversed lobe 36.4' are the same; that is, both profiles consist of a single pair of flanks, but, depending on whether a normal insert 62.4 or a mirror insert 62.4' is involved, the flanks are either at one level or the other. With respect to the direction in which the spring-loading 13.4 acts on the tumbler, the normal lobe 36.4 has an upper outer flank 37.4 and an upper inner flank 38.4, whereas the reversed lobe 36.4' has a lower outer flank 37.4' and an lower inner flank 38.4'.

In the present case, the two flanks have different shapes. As can be seen in Figure 7.3a, the upper inner flank 38.4 is essentially parallel to the transverse plane 31.7 of the cylinder core 20.4, whereas the upper outer flank 37.4 is at a certain angle to that plane. This applies not only to the normal insert 62.4 but also in analogous fashion to the mirror insert 62.4' according to Figure 8.2a with respect to the corresponding lower outer flank 37.4' and inner flank 38.4'.

In the case of the fourth exemplary embodiment as well, the tumblers 31.4-34.4 again have the cutouts 26.4, which, in the present case have a very simple, symmetrical design. In the middle of each cutout 26.4 there is a separating web 74.1-74.4. Although the web is essentially in the middle of the cutout, its length in the direction in which the spring force acts can be different from that of other webs in certain cases, depending on the position of the control edge 41.4-44.4. The profile is also simplified in the sense that, in the case of the tumblers 31.4 with the lowest control edge 41.1, the length of the separating webs 74.1 and 74.4 is the same as in the case of the tumbler 34.4, which has the highest control edge 44.4. In analogous fashion, the lengths of the separating webs 74.2 and 74.3 of the two tumblers 32.4 and 33.4, which have their control edges 42.4

and 43.4 in two different middle height positions, are also the same. The second variation of the profiling consists in that the bottom ends of the cutouts 26.4 begin at different distances 76.1-76.4 from the associated longitudinal centers 75.1-75.4 of the four different tumblers 31.4-34.4, as can be seen in Figures 7.1a, 7.3a, 7.4a, and 8.1a.

As can be derived from Figure 8.3a, two pairs of opposing flanks are located in each cutout on the tumbler 32.4 with the separating web 74.2. The two flanks 27.4i, 28.4i of the one pair extend along the two edges of the separating web 74.2; because they are located at the inner ends of their respective cutouts, on the web, they are therefore called the "inner flanks". The two other opposing flanks 27.4a and 28.4a are formed by the interior edges of the outer ends of their respective cutouts 26.4 and are therefore called the "outer flanks". The inner flanks 27.4i and 28.4i face away from each other, whereas the outer flanks 27.4a and 28.4a face each other. In this case, too, the inner flanks 27.4i and 28.4i are essentially parallel to the transverse plane 71.4, whereas the outer flanks 27.4a and 28.4a are at an angle to this plane and are designed essentially as mirror images of each other.

Figures 7.1a-8.4a show the relationships which exist in the

resting state. In Figures 7.1a-7.4a, the control edges 41.4, 42.4, and 43.4 of the tumblers 31.4, 32.4, and 33.4 occupy a uniform height position in the cylinder housing 10.4 marked by the line 50.4. This applies initially for those tumbler locations at which a normal insert 62.4 has been inserted into the cylinder core 20.4. But even when a mirror insert 62.4 is used, as shown in Figure 7.2a, the control edge 41.4 of the tumbler 31.4 still remains at this same height position 50.4. The positions of the control edges 41.4-44.4 are therefore concealed in a highly effective way.

The same is true for the tumblers 32.4, 33.4, and 34.4 according to Figures 8.2a-8.4a, when mirror inserts 42.4 have been introduced into the cylinder core 20.4. Now the associated control edges 42.4, 43.4, and 44.4 are in the height position designated 50.5. According to Figure 8.1a, however, when a normal insert 62.4 is used, the control edge 44.4 of the tumbler 34.4 is also at this same height 50.5. It is therefore impossible for an unauthorized person to tell which of the four possible tumblers 33.1-34.1 is present in any one of the locations in the cylinder housing 10.4. It is therefore impossible to make a copy of the key.

For the fourth exemplary embodiment as well, Figures 7.1b-

8.4b show, in analogy to Figures 4.1b-5.3b, the relationships which result when the tumblers 31.4-44.4 are pushed down as far as possible by a lock-picking tool against the spring-loading 13.4. In analogy to Figures 7.1a-7.4a, after the tumblers 31.4, 32.4, and 33.4 have been pushed down, the control edges 41.4, 42.4, and 43.4 are then located in the same height position 60.5 as shown in Figures 7.1b-7.4b. The same is true, as shown in Figures 8.1b-8.4b, for the pushed-down tumblers 32.4, 33.4, and 34.4, where the control edges 44.4, 42.4, and 43.4 occupy the same height position 60.6. In this case, too, the pushed-down tumblers 31.4 in the one case and 34.4 in the other are each on the same height level 60.5, 60.6, regardless of whether a normal insert 62.4 or a mirror insert 62.4' is present in the cylinder core 20.4. The actual positions 41.4-44.4 of the four tumblers 31.4-34.4 are thus concealed in the most effective way possible in each case.

According to the fourth exemplary embodiment, a set of different combs 68 according to Figure 6 can be assigned to a plurality of similar cylinder cores. The teeth of these combs are formed by the inserts 62.2 or 62.3, which have different lobe profiles. This increases the number of possible lock cylinder variants, because any one of these different combs can

be selected and inserted into one of these cylinder cores 20.2 or 20.4. This also applies to the simpler case explained for the fourth exemplary embodiment, where the teeth of the combs have identical lobe profiles but are arranged as mirror images 62.4 or 62.4' of each other in different sequences along the length of the comb 68. It is sufficient, as previously explained, to alternate between a normal insert 62.4 and a mirror insert 62.4' in the comb 68 according to Figure 4. If an even number of teeth is used in the comb 68 to realize this principle, the key point is then to decide which end of the comb 68 is to be inserted first into the lock cylinder 20.4. As explained on the basis of Figures 7.1a-8.4a, either height position 50.4 or height position 50.5 will be obtained for all four of the different tumblers 34.1-34.4. With minimal effort, and with the simplest design, a maximum of concealment is obtained for the actual positions of the control edges 41.1-41.4 in the cylinder housing 10.4.

List of Reference Numbers

- 10.1 cylinder housing (Figures 1.1-2.2b)
- 10.2 cylinder housing (Figures 3.1a-3.2a)
- 10.3 cylinder housing (Figures 4.1a-5.3b)
- 10.4 cylinder housing (Figures 7.1a-8.4a)
- 11 bearing bore in 10.1 (Figure 1.1a)
- 12.1 locking channel in 10.1 (Figure 1.1a)
- 12.2 locking channel in 10.2 (Figure 3.1a)
- 13.1 force arrow of the spring-loading (Figure 1.1a)
- 13.2 force arrow of the spring loading (Figure 3.1a)
- 13.3 force arrow of the spring loading (Figure 4.1a)
- 13.4 force arrow of the spring loading (Figure 7.1a)
- 14 bottom surface of 16.1 (Figure 1.1a)
- 15.1 compression spring (Figure 1.1a)
- 15.2 compression spring (Figure 3.1a)
- 15.3 compression spring (Figure 4.1a)
- 15.4 compression spring (Figure 7.1a)
- 16.1 escape channel in 10.1
- 16.2 escape channel in 10.2
- 17 bottom surface of 12.1 (Figure 2.2a)
- 18 height offset of 31.1 between 30.2 and 30.4 (Figure 2.2a)

19 tumbler width of 36.1 (Figure 2.1a)

20.1 cylinder core (Figures 1.1a-2.2b)

20.2 cylinder core (Figures 3.1a-3.2a)

20.3 cylinder core (Figures 4.1a-5.3b)

20.4 cylinder core (Figures 7.1a-8.4a)

21.1 guide surface for 30.1 on the lobe side (Figure 1.1a)

21.2 guide surface for 30.2 on the lobe side (Figure 3.1a)

22.1 guide surface for 30.1 on the opposite side (Figure 1.1a)

22.2 guide surface for 30.2 on the opposite side (Figure 3.1a)

23.1 shaft in 20.1 (Figure 2.1a)

23.2 shaft in 20.2 (Figure 3.1a)

24.1 expansion of 23.1

24.2 expansion of 23.2

25 end surface of 24.1 (Figure 1.1a)

26.1 cutout in 20.1

26.2 cutout in 31.2, 33.2

26.3 cutout in 31.3-34.3

26.4 cutout in 31.4-34.4

27.1 first opposing flank of 36.1 (Figures 1.1a-2.2b)

27.2 first opposing flank of 36.2 (Figures 3.1a-3.2a)

27.3a outer opposing flank of 36.3 (Figures 4.1a-5.3b)

27.3i inner opposing flank of 36.3 (Figures 4.1a-5.3b)

27.4a outer opposing flank of 36.4 (Figures 7.1a-8.4a)

27.4i inner opposing flank of 36.4 (Figures 7.1a-8.4a)

28.1 second opposing flank of 36.1 (Figures 1.1a-2.2b)

28.2 second opposing flank of 36.2 (Figures 3.1a-3.2a)

28.3a outer opposing flank of 36.3 (Figures 4.1a-5.3b)

28.3i inner opposing flank of 36.3 (Figures 4.1a-5.3b)

28.4a outer opposing flank of 36.4 (Figures 7.1a-8.4a)

28.4i inner opposing flank of 36.4 (Figures 7.1a-8.4a)

29 open width of shaft 23.1 (Figure 2.1a)

30.1 longitudinal plate edge of 31.1, 30.3 on the lobe side (Figures 1.1a, 3.1a)

30.2 longitudinal plate edge of 31.1, 32.2 on the opposite side (Figures 1.1a, 3.1a)

31.1 tumbler with 41.1 for 20.1

31.2 tumbler with 41.2 for 20.2

31.3 tumbler with 41.3 for 20.3

31.4 tumbler with 41.4 for 20.4

32.1 tumbler with 42.1 for 20.1

32.3 tumbler with 42.3 for 20.3

32.4 tumbler with 42.4 for 20.4

- 33.1 tumbler with 43.1 for 20.1
- 33.2 tumbler with 43.2 for 20.2
- 33.3 tumbler with 43.3 for 20.3
- 33.4 tumbler with 43.4 for 20.4
- 34.1 tumbler with 44.1 for 20.1
- 34.3 tumbler with 44.3 for 20.3
- 34.4 tumbler with 44.4 for 20.4
- 35.1 spring-supporting projection on 31.1-34.1 (Figure 1.1a)
- 35.2 spring-supporting projection on 31.2, 33.2 (Figure 3.1a)
- 36.1 lobe on 30.1-34.1 (Figures 1.1a-2.2b)
- 36.2 lobe on 62.3 (Figure 4.1a)
- 36.3 normal lobe on 62.3 (figure 4.1a)
- 36.3' reversed lobe on 62.3', reversed position of 62.3 (Figure 4.3a)
- 36.4 normal lobe on 62.4 (Figure 7.1a)
- 36.4' reversed lobe on 62.4', reversed position of 62.4 (Figure 7.2a)
- 37.1 first flank of 36.1 (Figures 1.1a-2.2b)
- 37.2 first flank of 36.2 (Figures 3.1a-3.2a)
- 37.3a first outer flank of 36.3 and 36.3' (Figures 4.1a-5.3b)
- 37.3i first inner flank of 36.3 and 36.3' (Figures 4.1a-

5.3b)

- 37.4 upper outer flank of 36.4 and 36.4' (Figures 6-8.4b)
- 37.4' lower outer flank of 36.4 and 36.4' (Figures 6-8.4b)
- 38.1 second flank of 36.1 (Figures 1.1a-2.2b)
- 38.2 second flank of 36.2 (Figures 3.1a-3.2a)
- 38.3a second outer flank of 36.3 and 36.3' (Figures 4.1a-5.3b)
- 38.3i second inner flank on 36.3 and 36.3' (Figures 4.1a-5.3b)
- 38.4 upper inner flank of 36.4 (Figures 6-8.4b)
- 38.4' lower inner flank on 36.4' (Figures 6-8.4b)
- 39 lower plate edge of 31.1 (Figure 1.1)
- 40.1 height center line of 31.1-34.1
- 40.2 height center line of 31.2-33.2
- 41.1 control edge of 31.1
- 41.2 control edge of 31.2
- 41.3 control edge of 31.3
- 41.4 control edge of 31.4
- 42.1 control edge of 32.1
- 42.3 control edge of 32.3
- 42.4 control edge of 32.4
- 43.1 control edge of 33.1
- 43.2 control edge of 33.2

43.3 control edge of 33.3
43.4 control edge of 33.4
44.1 control edge of 34.1
44.3 control edge of 34.3
44.4 control edge of 34.4
45 first step height, height position of 41.1-41.4
46 second step height, height position of 42.1-42.4
47 third step height, height position of 43.1-43.4
48 fourth step height, height position of 44.1-44.4
49 upper plate edge of 34.1 (Figure 2.2a)
50.1 height position of 30.1, 30.3 (Figures 1.1a, 2.2a)
50.2 height position of 32.1, 32.4 (Figures 2.1a, 2.2a)
50.3 height position of 31.2, 33.2 (Figures 3.1a, 3.2a)
50.4 height position of 31.4, 32.4, 33.4 (Figures 7.1a-
7.4a)
50.5 height position of 34.2, 34.3, 34.4 (Figures 8.1a-
8.4a)
51 distance of 50.1 from 27.1 (Figure 1.2a)
52 height offset, distance of 50.2 from 27.1 (Figure
2.2a)
53 tumbler web of 33.1 (Figure 1.2)
54 first cutout in 53 (Figure 1.2)

55 second cutout in 53 (Figure 1.2)
 56 external profile of 35 (Figure 1.2)
 57 set of teeth at the end of 34.1 (Figure 2.2b)
 58 set of opposing teeth in 12 for 57 (Figure 2.2b)
 59 set of opposing teeth in 16 for 57 (Figure 2.2b)
 60.1 height position of 31.1, 33.1 (Figures 1.1b, 1.2b)
 60.2 height position of 32.1, 34.1 (Figure 2.1b, 2.2b)
 60.3 height position of 31.3, 32.3, 33.3 (Figures 4.1b-
 4.3b)
 60.4 height position of 32.3, 33.3, 34.3 (Figures 5.1b-
 5.3b)
 60.5 height position of 31.4, 32.4, 33.4 (Figures 7.1b-
 7.4b)
 60.6 height position of 32.4, 33.4, 34.4 (Figures 8.1b-
 8.4b)
 61.2 radial opening in 20.2
 61.3 radial opening in 20.3
 61.4 radial opening in 20.4
 62.2 insert in 61.2 (Figures 3.1a, 3.2a)
 62.3 normal insert in 61.3 (Figure 4.1a)
 62.3' mirror insert in 61.3, reversed position of 62.3
 (Figure 4.3a)
 62.4 normal insert in 61.4 (Figure 7.1a)

62.4' mirror insert in 61.3, reversed position of 62.3
(Figure 7.2a)

63.2 outer end of 62.2

63.3 outer end of 62.3 (Figure 4.2a)

63.4 outer end of 62.4 (Figure 6)

64.2 inner end of 62.2

64.3 inner end of 62.3

64.4 inner end of 62.4

65 external contour of 20.2 (Figure 3.1a)

66.2 length of 26.2 (Figure 3.2a)

67.1 lowering of 27.2 versus 40.2 (Figure 3.1a)

67.3 lowering of 27.2 versus 40.2 (Figure 3.2a)

68 comb (Figure 6)

69 tongue on 31.1-34.1 (Figures 1.1a-2.2a)

70 window in 31.1-34.1 (Figures 1.1a-2.2a)

71.3 transverse plane of 20.3 (Figure 4.2a)

71.4 transverse plane of 20.4 (Figures 7.1a, 7.1b)

72 distance between 36.4 and 71.4 (Figure 7.1a)

72' distance between 36.4' and 71.4 (Figure 7.2a)

73 upper end of 62.4 and 62.4' (Figure 6)

73' lower end of 62.4 and 62.4' (Figure 6)

74.1 separating web on 31.4 (Figure 7.1a)

74.2 separating web on 32.4 (Figure 7.4a)

74.3 separating web on 33.4 (Figure 7.3a)
74.4 separating web on 34.4 (Figure 8.1a)
75.1 longitudinal midpoint of 31.4 (Figure 7.1a)
75.2 longitudinal midpoint of 32.4 (Figure 7.4a)
75.3 longitudinal midpoint of 33.4 (Figure 7.3a)
75.4 longitudinal midpoint of 34.4 (Figure 8.1a)
76.1 distance of 26.4 from 75.1 on 31.4 (Figure 7.1a)
76.2 distance of 26.4 from 75.2 on 32.4 (Figure 7.4a)
76.3 distance of 26.4 from 75.3 on 33.4 (Figure 7.3a)
76.4 distance of 26.4 from 75.4 on 34.4 (Figure 8.1a)